Performance Evaluation of Leach in Wireless Sensor Network

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ABSTRACT

Wireless sensor network consists of large number of sensor nodes which is used to monitor physical or environmental conditions such as temperature, sound, vibration, pressure and cooperatively compute and transfer it to base station . These sensor nodes are sensitive to energy consumption and gets exhausted on working. So we need to emphasize on reducing energy dissipation of sensor nodes to improve the network lifetime . Various routing protocols are developed to enhance network scalability and stability. For this purpose we proposed a new routing method which improves the life span of network, its data transmitting capability with low energy consumption. It is an improvised version of LEACH protocol which conserves energy by load balancing and thus improving the lifetime of network.[10] Reduction of energy consumption is achieved with the help of TDMA scheduling. Time division multiple access (TDMA)-based MAC can potentially reduce the delay and provide real-time guarantees as well as save power by eliminating collisions The performance evaluation of protocol is based on simulation test performed in network simulator 2 (NS2) to prove the effectiveness of this proposed method in terms of network lifetime and energy efficiency.

Keywords : WSN ,BS , Clustering, Energy Efficiency.

I. INTRODUCTION

WSN is composed of sensor nodes capable of sensing ambient conditions in its surrounding, transmitters to transfer data from nodes to sink and a base station to receive sensed data from nodes placed in distant locations. There are thousands of battery operated sensor nodes deployed in distant location which are unattended , mostly self configuring and self organizing. [12] These sensor nodes communicate in peer-peer network, transferring data from one node to other till the destination in order to reduce energy consumption. As these nodes have limited life span, low processing capability and limited bandwidth which requires more energy to sense and transmit a data from an isolated region to base station. The real need of a WSN is to provide an optimal path between sensor node and a base station with lower energy consumption. An energy efficient routing protocol is required in transmission of data to improve network reliability and stability. The purpose of routing protocol is to minimize energy consumption and maximize sensor nodes capacity, to increase network lifetime by providing an optimal path.[11]

Clustering is the technique used in routing protocols to minimize the energy dissipation by balancing the energy consumption of sensor nodes present in network. It provides an energy efficient routing protocol which enhances the life span of network[11]. This technique divides the entire network into various disjoint sets known as cluster , every cluster is managed by a cluster head which is the highest

energy sensor node present in the network. All the sensor nodes in a cluster transmits data to their cluster head which compresses and delivers it to base station.In this paper we are introducing a technique which uses a TDMA scheduling for transmission of data to reduce delays and provide real time data with no collisions. This reduces the energy consumption of network by reducing collisions.

APPLICATION-

WSN has an immense potential in future research and development. Usage of Wireless sensor network will revolutionize our economy and life in the field of medicine, forecasting environmental conditions, military monitoring, security, smart city, factory monitoring etc.[1]

II. RELATED WORK

Over the years development in wireless sensor network technology has enabled reliable monitoring and analysis of unknown and untested environments. But still it has an immense scope of research in the field of energy conservation . To improve network capabilities various routing protocols are developed depending upon the type of network structure designed for the application or the network operations carried out using these protocols for a specific application model.[16]
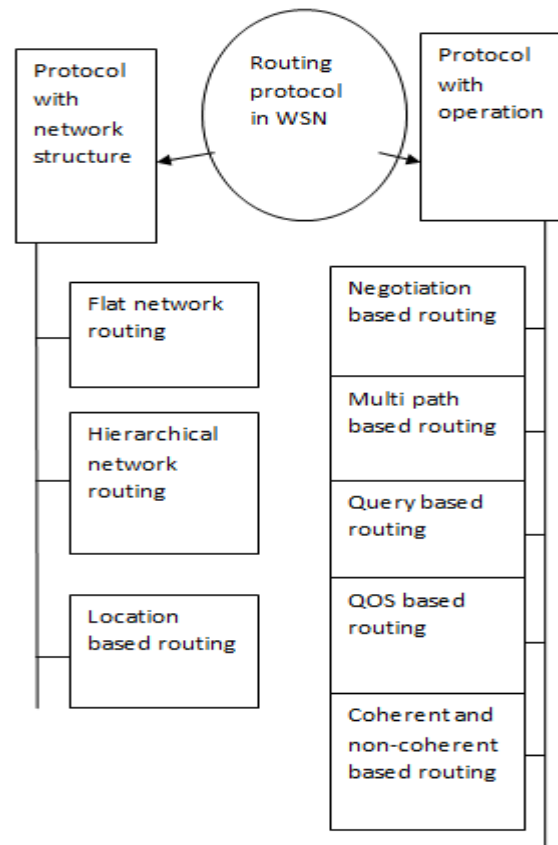

Figure 1. Types of routing protocol in wireless sensor network

FLAT ROUTING PROTOCOL - This protocol distributes information to any node that can be reached or receive information. All nodes in network are treated in same way and procure same function such as collecting data and communicating with the sink. No efforts are made for grouping of network. Eg: SPIN, Directed diffusion.

SPIN- Sensor protocols for information via negotiation

SPIN protocol is used to remove deficiencies due to flooding and gossiping technique. In flooding technique whenever a node receives a data it transmits it to all the nodes available on network and due to this whole network is flooded with the same data whereas in gossiping technique data is transmitted to randomly selected near by node which again selects a node to forward data. This is how data is transmitted to destination which is energy

efficient but not time efficient. So SPIN routing protocol was developed which uses data negotiation and resource adaptive algorithm for distribution of data.[19] The technique used in SPIN is to name data with high level descriptors or meta data. These meta data are advertised among the sensor nodes on receiving new data. Nodes who do not have data receives it by sending a request message. There are three messages in SPIN protocol to communicate among sensor nodes. ADV- This is used to advertise a particular message among nodes. REQ- this is used to request a data from a particular node. DATA- This is used to transmit the data.

The advantage of SPIN network is that topological changes are localized since each node needs to know only its single-hop neighbors. SPIN protocol removes many problem from flooding like passing of redundant data, resource blindness, overlapping .[13,14]

One of the drawback of SPIN is that if nodes in between the source and destination are not interested in receiving data, data will not be transferred to destination. As the middle link will not generate and transmission of data will not be possible, this will lead to packet dropout and delay in communication. Due to this real time data will be delayed.

HIERARCHICAL ROUTING PROTOCOL-

Hierarchical protocol organizes its network in a hierarchy, higher energy nodes are used to aggregate and send the information whereas low energy nodes are used to sense the data. Clustering is the technique in which sensors are gathered into a disjoint set known as cluster and one of the sensor node acts as the head of a cluster, which communicates compressed information to the base station. Nodes that are not cluster head only communicate with the cluster head in a TDMA fashion, according to the schedule created by the cluster head. [6][7].This

technique plays an important role in scalability and stability of network
Example- LEACH, TEEN, APTEEN.
LEACH- Low energy adaptive clustering hierarchy
It is one of the energy efficient hierarchical routing protocol. This routing protocol use a clustering method to transmit data in order to obtain advantage on reduction of energy consumption. [1] . In this method whole network is divided into several group known as cluster and each cluster is ruled by a cluster head which is randomly selected on the bases of energy level. All the other low energy node senses the data from surrounding and transmit it to the cluster head, where it aggregates and communicate it to Base Station. This reduces the energy consumption as transmission will only be done by cluster head rather than all sensor nodes. A TDMA schedule is created for the transmission of data to base station , this reduces collision and saves energy.
LEACH routing protocol operations are based on rounds. Each round goes through two phases.[4,5]

B. SETUP PHASE -

Cluster and Cluster head are created in this phase. Cluster head is selected randomly among the nodes whose dissipated energy is less than all the other nodes. In this phase all the nodes select a random number between 0 and 1. Sensor node whose number is lesser than the pre defined threshold T (n). That node becomes a cluster head and this is determined by a formula.

$$T(N) = \frac{P}{1 - P\left(r\ mod\ \frac{1}{P}\right)} \qquad \forall n \in G$$

Where T(n) is threshold, P is probability of selection of node as cluster head, r is the present round, G is the node that is not selected as cluster head in 1/p round.[2][3]

In this way every node has an equal opportunity to serve as a cluster head.

C. STEADY STATE PHASE –

Selected cluster head will advertise a message to all the nodes and provide a time slot for a response from sensor nodes. Nodes compute data from surrounding and transmit it to CH in a given time duration otherwise remain in a sleeping mode. This reduces the energy consumption and network lifetime is improved. The data received by cluster head is processed, compressed and sent to the base station. Leach protocol also uses CDMA so that each cluster uses a different set of CDMA codes, to minimize collision between clusters. This reduces delay and is efficient in sending real time data.[1][8][9]

LOCATION BASED ROUTING PROTOCOL - In this

routing protocol sensor nodes are addressed with the help of their location. Their location is obtained by GPS(Global Positioning System) and receiving radio signals. It is obtained to calculate the distance between two nodes , in order to assume energy consumption.

Example- GAF, GEAR

GEAR- Geographic and energy aware routing protocol GEAR is an energy efficient routing protocol. It addresses sensor nodes with the help of their location . Every node must equip a GPS system or localization system in order to know their neighbours location and their own position. This information is used to calculate distance between two nodes and to assume energy consumption for transmission of data.Sensor nodes are aware of their residual energy which helps in routing a packet from energy efficient route to its destination. Then, GEAR uses a recursive geographic forwarding algorithm to disseminate the packet inside the target region.[11,12,16]

NEGOTIATION ROUTING PROTOCOL-

Flooding technique used for transmission of data causes implosion and overlapping of data . . Due to this duplicate copy of data is transmitted which is wastage of energy and processing of nodes . So this protocol is used to remove redundant data from transmitting to other nodes through negotiation. [6,7]

MULTI PATH ROUTING PROTOCOL- These are the routing protocols that uses multi path for sending data rather than a single path . This acts an alternate path for transmitting data if main path fails. Periodically messages are sent through these path, to keep it alive. In this way network reliability is increased on the cost of energy efficiency.[7]

QUERY BASED ROUTING PROTOCOL- In this protocol a node broadcast a query in the network to obtain a data from other nodes.

Node whose data matches the query will reply back to the initiated node.

QOS ROUTING PROTOCOL- Along with the minimization of energy consumption , we need to provide a quality data to BS. Some of its quality of service requirements are to maintain delay, network reliability, bandwidth availability, fault tolerance etc[7,16]. Thus QOS protocol is used to balance energy dissipation and data quality.

COHERENT AND NON COHERENT BASED ROUTING PROTOCOL-

Data processing is an important task in transmission of data in wireless sensor network. There are two types of data processing technique-Coherent data processing in which minimum processing of data is done on initial node and further processing is done on aggregators. Minimum processing tasks are time stamping, removal of redundancy etc. Non coherent data processing – In this technique data goes through 3 phases.

1. Target detection, data collection, and preprocessing
2. Membership declaration
3. Central node election.

It has low data traffic loading.[16]

One of the main challenge in development of routing protocol is energy constraint. As sensor are deployed in harsh and isolated environment, there is scarcity of energy resources. So the objective of developing new protocol should be as energy efficient as possible to prolong individual lifetime of sensor node and hence

network lifetime We have designed an improvised LEACH protocol by modifying some of its attributes. Its proposed methodology is explained along with a flow chart.

PROPOSED METHODOLOGY-

1.1 Description of proposed routing protocol-

Myriad routing protocols are developed for energy efficient communication. Every day changes are made in these protocol for a better protocol. We have also improved LEACH routing protocol in order to increase its efficiency.
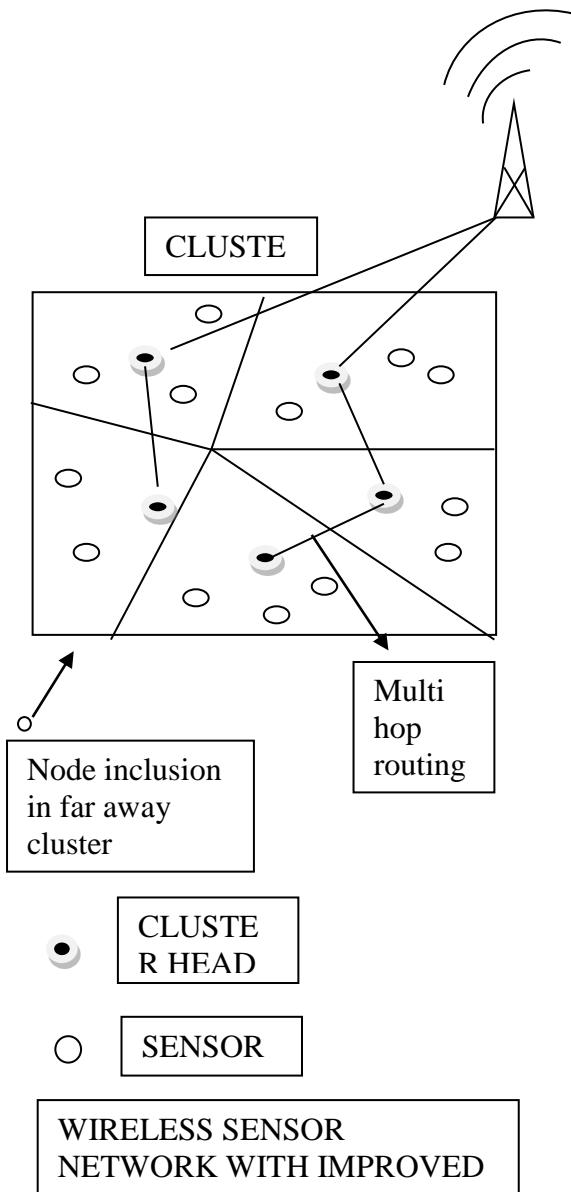

Figure 2. Proposed network model

In our routing protocol we have assumed base station to be static and have unlimited energy residues and communication power. Sensor nodes are placed in isolated area either nearer or far away from base station.

The longer the distance between base station and sensor nodes , higher is the energy dissipation in transmission of data . All nodes present in network are grouped into disjoint sets known as cluster and one with the highest energy in a cluster becomes a cluster head. Thus number of cluster head are equal to number of clusters in network. Cluster head has a special responsibility of aggregating data from all the sensor nodes and communicating it to BS.[15]

In this figure most of the sensor nodes are nearer to BS in order to reduce energy consumption in communication whereas far away nodes communicate through multi hop route to maintain energy residue. In multi hop routing data is transmitted from one cluster head to other and obtain an optimal path to base station.

As we know nodes in farthest cluster require more energy for communication which leads to energy exhaustion and network failure. So to compete with this problem a random node is added continuously to replace a dyeing node. This enhances network lifetime.

To improve scalability and stability in network we have introduced CSMA/CA protocol for the transmission of data between sensor nodes and its cluster head ,and TDMA scheduling between cluster head and base station . These protocols are used to prevent collision during transmission of data and to deliver real time data to user. Due to this routing

protocol become more energy efficient as well as time efficient.

With the help of this proposed methodology we had tried to make efficient utilization of energy residue of a sensor node and to obtain real time functionality. This ultimately improves network lifespan and provides regular update to base station.

FLOW CHART FOR CLUSTER FORMATION AND DATA TRANSMISSION
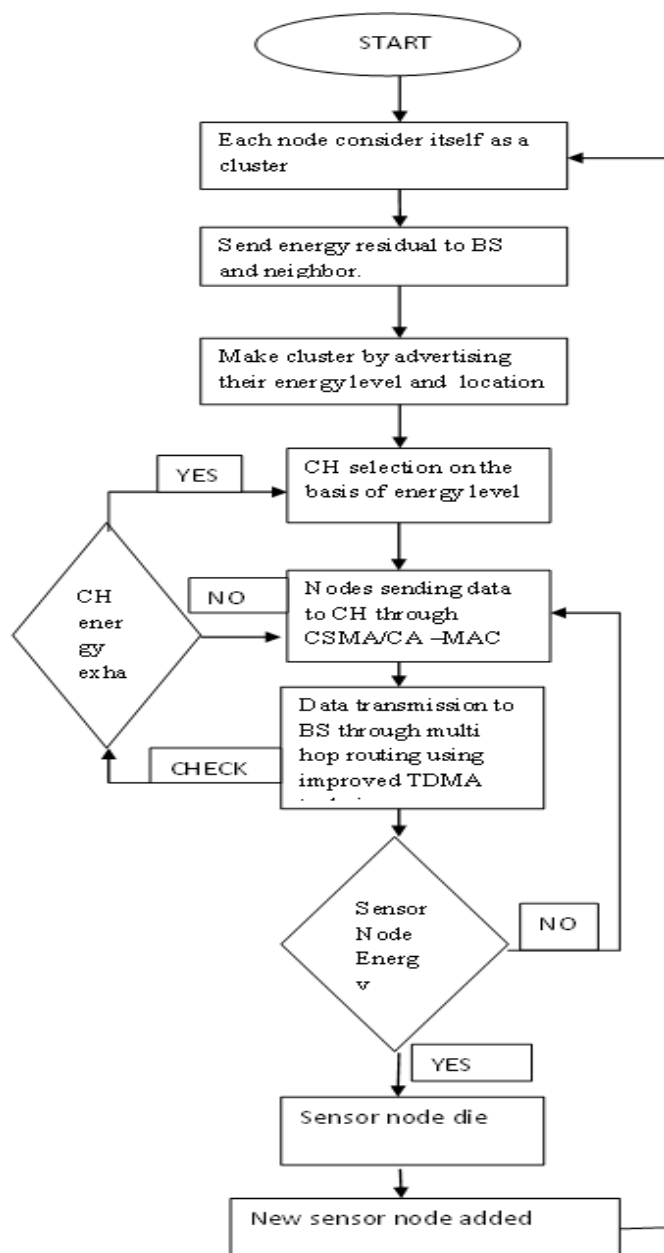
ACTIVATION PACKET-

Table1. Parameter and Value

Parameter	Value
Network size	100m*100m
Initial energy	.5j
p	.1j
Data aggregation energy cost	50pj/bit j
Number of nodes	100
Packet size	200 bit
Transmitter electronics	50nj/bit
Receiver electronics	50nj/bit
Transmit amplifier	100pj/bit/m2

This is the activation packet used to initialize network. We had used these values to initialize node and to develop a network. Our network size is 100m*100m and square shaped. Number of nodes deployed in our network are 100 and their initial energy is 0.5j. These values are applied on our proposed methodology and results were obtained through simulation test.

PROPOSED ALGORITHM-
1. Initialization of method-
Firstly network is initialized by using activation packet and each node is assumed as a cluster.
2. Start up phase-
Cluster head selection- It is based on CEL(current energy level) and REL(residual energy level). In the startup phase first of all advertisement is done using a MAC protocol based on distance between base station and node itself.

Selection of cluster head is based on the formula.

$$T(N) = \frac{P}{1 - P\left(r \, mod \frac{1}{P}\right)} \quad \forall n \in G$$

Where p- Desired cluster head percentage

r-current round

h-set of nodes which have not been CH in 1/p

3. Cluster formation –

Cluster formation is based on information received on signal strength of nodes through advertisement message.

Each non cluster head node transmits a joint request message back to its closest cluster head using CSMA/MAC protocol.

Now cluster head node will setup a transmission schedule likewise TDMA method.

4. Data transmission is done in a specific proposed schedule that is through improved TDMA. Collection of data is done in a reserved time slot and it follows multi hop routing for data transmission.

5. Random node inclusion in cluster-

If energy residue is exhausted in sensor node, cluster dies. To keep it alive new sensor node are added .

SIMULATION AND RESULT

SIMULATION TOOL- This thesis uses Network Simulator NS2 as experiment platform. NS 2 is an open source discrete event simulator which is used by the research community for the purpose of research in networking domain. It has support for both wireless and wired networks and may simulate several network protocols such as UDP, TCP, multicast routing, etc. Recently, support has been added for simulation of ad hoc wireless and large satellite networks. The NS 2 simulation software was developed at the University of Berkeley. It is constantly under further development by an active group of researchers. In this thesis version NS 2.28 has been used for simulation.
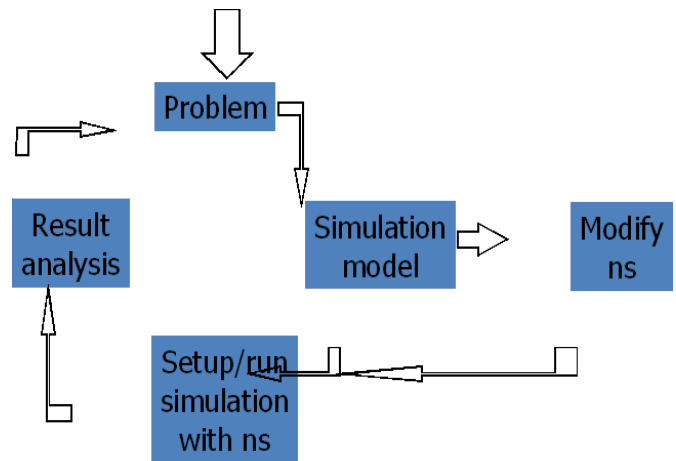

Figure 3. Working model of NS

NS uses simple model with single thread of control and without locking or race conditions to worry about which is very easy to understand.

NS2 GOALS

To support networking research and education

- Protocol design, traffic studies, etc.
- Protocol comparison;
- New architecture designs are also supported.

To provide collaborative environment

- Freely distributed, open source;
- Increase confidence in result

NETWORK ANIMATOR(NAM)

Nam is a Tcl/TK based animation tool for viewing network simulation traces and real world packet traces. It supports topology layout, packet level animation, and various data inspection tools. It is mainly intended as a companion animator to the ns simulator. When we will run the program in ns then we can visualize the network in the NAM.

RESULT

Initially we had input values in NS 2 simulation software and then results were viewed with the help of Network Animator.
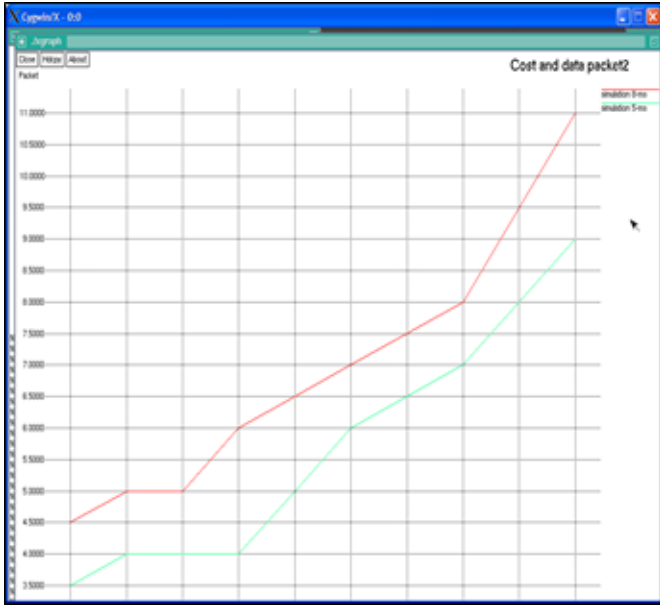
Figure 4. network model Result

In this graph we have shown the Cost of data packet sending in different time slot. Here we generate a XY axis graph between Time and data packet. In the X-axis we will take a SIMULATION TIME and in the Y-axis we will take DATA PACKETS.

In graph it shows red line (modified leach) has higher rate of data transmission as compared to present leach. It sends lower data packets which is shown in green line.

We clearly see that in table our proposed method sends 10000 more data packets from present Leach .

Table 2. To compared with present leach and Modified Leach

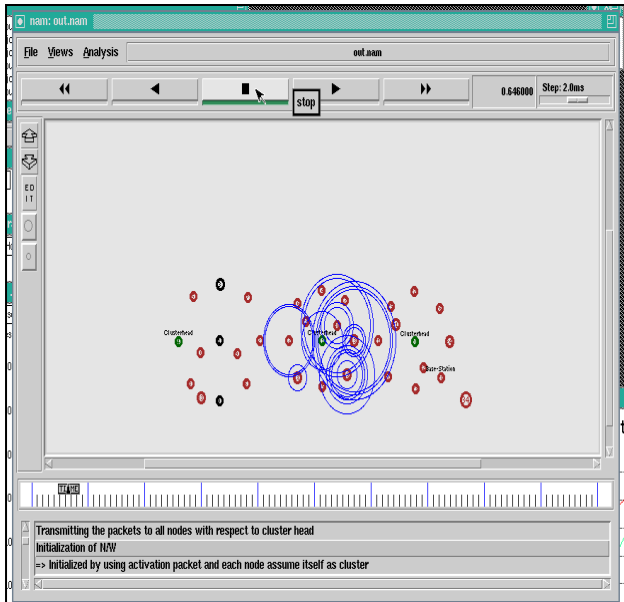| Time	Modified Leach	Leach
0.1	45000	35000
0.2	50000	40000
0.3	50000	40000
0.4	60000	40000
0.5	65000	50000
0.6	70000	60000
0.7	75000	65000
0.8	80000	70000
0.9	95000	80000

Figure 5. network model Result

In this clusters are formed and their cluster heads are selected. Red one's are the sensor nodes and green one's are cluster head, blue circle denotes transmission of data.

These graph shows the performance of proposed methodology. They compare our proposed method with the present methodology of Leach protocol.
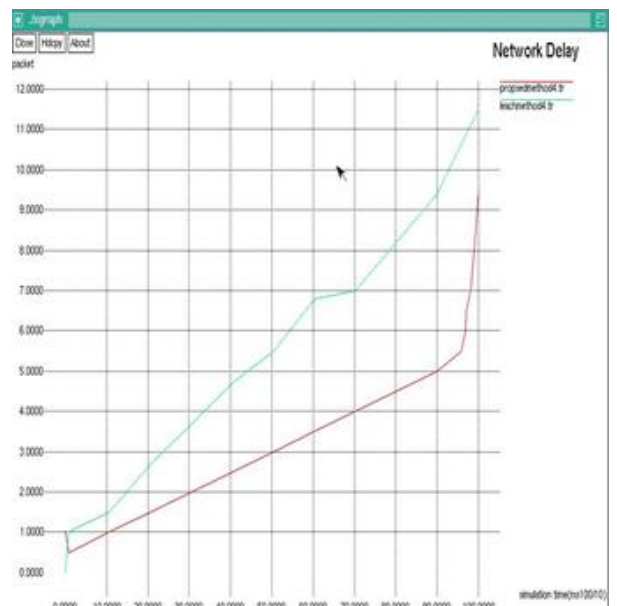

Figure 6. network model Result

Here in this graph we have shown the second result that is based on the Network delay. Network delay is an important design and performance characteristic of a computer network like Wireless Sensor network or telecommunications network. The delay of a network specifies how long it takes for a bit of data to travel across the network from one node or endpoint to another. It is typically measured in multiples or fractions of seconds. Delay may differ slightly, depending on the location of the specific pair of communicating sensor nodes. Although users only care about the total delay of a network. Here in this graph green line specifies leach and red line denotes modified leach. we had compared Network delay of leach and our proposed method , so clearly see that the Network Delay of our proposed method is much lower as compare to the present leach. Reason behind them is that in our proposed method we have use multi hop leach in which packet are not send directly to the base station, instead from an optimal path through various sensor nodes. It works as a relay station and helps in reducing energy consumption of CH.
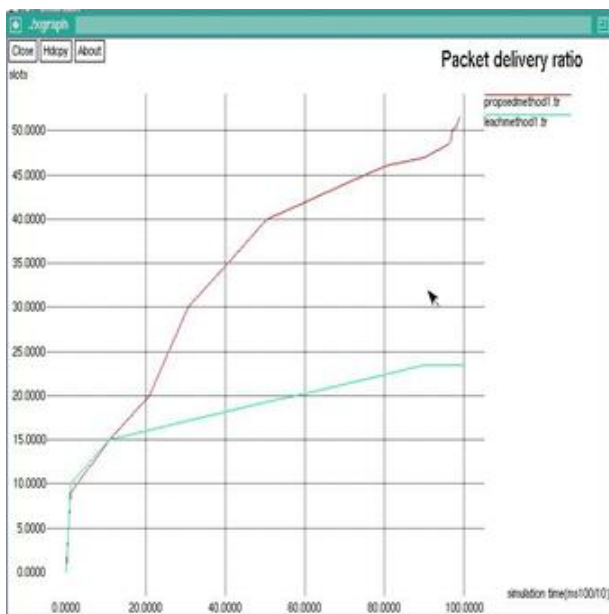

Figure 7. network model Result

Packet delivery ratio - If you want to evaluate the performance of protocol using NS-2, first you have to define the evaluation criteria. This time I want to

explore about Packet delivery ratio, packet lost and end to end delay.

Packet delivery ratio: The ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.

PDR =∑ Number of packet receive / ∑ Number of packet send

The greater value of packet delivery ratio means the better performance of the protocol.

End-to-end Delay: The average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.

EED=∑ (arrive time – send time) / ∑ Number of connections

The lower value of end to end delay means the better performance of the protocol.

This graph shows that the packet delivery ratio between our proposed method and op-leach method. In the X- axis we assign Simulation Time and in Y – axis we show slots. In multi hop routing protocol packet delivery ratio plays an important role for checking the network performance. Here we will clearly see that the packet delivery ratio of our proposed method is much higher as compared to leach.
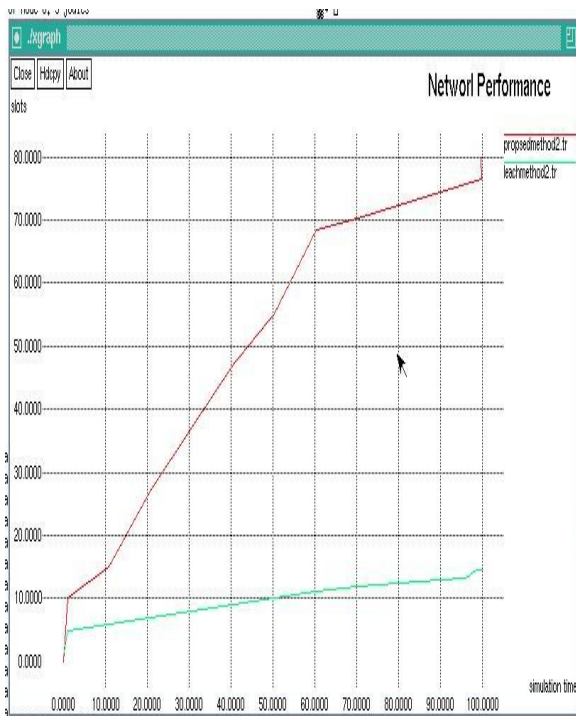
Figure 8. network model Result

Again Network Performance plays an important role for checking or testing the performance of LEACH protocol in WSN. In the Network performance we will create a graph in between simulation time and slots. This graph indicates that our proposed method provides a better network performance.

III. CONCLUSION

In this paper we have discussed various routing protocols developed for wireless sensor network. The main concern of our survey is efficient usage of energy residue of sensor nodes in network and enhancing their lifetime. We had tried to maintain data quality along with energy efficiency. This method uses multi hop routing for transmission of data and CSMA/CA, TDMA for avoiding collision and delay of data. A random node is added to the far away cluster for improving network lifetime . We had compared our simulation result on the basis of network performance, network delay, packet delivery ratio and data packet and achieved satisfactory result for our proposed method.

IV. FUTURE SCOPE

wireless sensor network is an emerging technology with immense scope of research and development. In this field energy is the main constraint and has huge research possibility. Certainly further energy improvement is possible by improving routing protocol and cluster head selection technique.

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